THE INFLUENCE OF ACUASTOC ON SOIL MOISTURE AND SOME MORPHO-PHYSIOLOGICAL PROPERTIES IN MAIZE CROP

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Abstract
In this paper, I studied the influence of Acuastoc on soil moisture and some morpho-physiological properties (average plant height and leaf chlorophyll content) was studied in maize cultures. Acuastoc consists of 20% hydrogel (Aquasorb) and 80% zeolite. Aquasorb is a copolymer of aclimamide and potassium acrylate, which plays a role in water retention during wet periods, as well as in water release during drought periods. Zeolite (also known as "boiling rock" or "wonder rock") was discovered by the Swedish mineralogist Baron Axel Fredrik Cronstedt in 1756, by heating mineral stilbite with a blowing flame. This has a high cationic exchange and water retention capacity. The use of Acuastoc in the agricultural sector, in the context of global climate change, can be an optimal solution to reduce the negative effects caused by the uneven distribution of rainfall over the entire vegetation period. The study was carried out in vegetation vessels, and the work variants were as follows: Variant V_1 (control) without treatment, V_2, treated with 100 kg ha^{-1} of Acuastoc, V_3 without treatment, but subject to periods of water stress, and V_4 treated with 100 kg ha^{-1} Acuastoc and subject to periods of water stress. Water stress was induced to plants after sunrise, from the 4-6 leaf stage, by reducing the number of waterings by half compared to Variants V_1 and V_2. The soil in the vegetation vessels was characterized by a pH of 6.29, a humus content of 2.9%, a total N of 0.11%, a P AL of 29.5 mg kg^{-1}, and a K AL of 183 mg kg^{-1}. The results revealed a significant influence of Acuastoc on the analyzed parameters especially in water stress conditions.

Key words: Acuastoc, Zeolit, maize, morphological properties, soil moisture

Acuastoc is formed of a mixture of Aquasorb (20%) and a zeolite rock of volcanic origin, found in a percentage of 80%. Zeolite (also known by the name “the boiling rock” or “wonder rock”) was discovered by the Swedish mineralogist Baron Axel Fredrik Cronstedt in 1756, by warming mineral stilbite with a blowing flame (Gusenius E.M., 1969).

Most of the initial research regarding the use of zeolites in agriculture took place in the 1960’s in Japan, the Japanese farmers using the zeolite rock to control the content of humidity, the unpleasant smell from the stable waste, and to increase the pH of acid soils (Minato and Hideo, 1968).

The natural zeolites are a group of minerals that contain natural aluminosilicate hydrated by calcium, strontium, sodium, potassium, barium, magnesium. In nature, zeolites were formed by the deposit of volcanic ash in lakes with salted water. The zeolites are natural products, non-toxic, without contraindications and they do not pollute the environment.

The natural zeolites assure the necessary of macro and microelements, such as: Fe, Ca, Mg, Na, P, Cu, Zn, Mn, Si, Al, Cr. They can be used in agriculture to enrich the sandy soils and the acid soils with potassium and magnesium. Also, the natural zeolites products can be used to reduce the concentration of chlorine in the composition of soils, without modifying their pH. As shown by Mumpton, 1999, zeolites are considered useful in the agricultural sector, due to some properties, such as: high capacity of cationic exchange; high capacity to retain water in free canals; high capacity of adsorbtion. Thus, zeolites improve the efficiency of using water in the agricultural sector by increasing in soil the capacity to retain water in the humid periods and give it to plants in drier periods (Xiubin H., Zhanbin H., 2001; Benardi A.C.C. *et al.*, 2010).

Zeolites retain water in their porous structure, which means that plants always have a reservoir of water and nutritive substances, easily available in soil. The combination of these effects reduces the consumption of water and fertilizers, because less water is lost due to the infiltration and evaporation, and the fertilizers are lost less, due to the leak.

The positive properties of the zeolite are accentuated by the hydrogel Aquasorb (found in a percentage of 20% in Acuastoc), which make it

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sellable for the agricultural sector, especially in the context of global climatic changes, where the non-uniform distributions of the precipitations often cause problems of agro-technical kind.

The use of Acuastoc (Zeolit 80% + Aquasorb 20%) in the agricultural sector has a considerable potential because it influences positively a large variety of processes, from those involved in the cationic exchange to those of absorption-desorption of water and nutrients. Aquasorb is a co-polymer of acrylamide and potassium acrylate, which functions in cycles of absorption-desorption of water and nutrients. It has a high capacity to retain an important volume of water (Hany El-Hamshary, 2007), in the humid periods its absorbs the water, becoming expanded to a large extent, and in the dry periods it frees water and nutrients to plants, by its actions becoming useful for plants and soil (Claire Farrell, *et al*, 2013; Sepaskhah A.R., *et al*, 2006; Sepaskhah A.R. and Mahdi-Hosseinabadi Z., 2006; Peterson D., 2009; An Li, *et al*, 2005).

The use of Acuastoc can be seen as an alternative agro-technical method of fight against some unwanted events, such as on the one hand, a part dryness of moderate intensity, but especially against non-uniform distribution of the precipitations, especially in the area of impact of the study, where in the latest years these phenomena have manifested with high frequency. In this sense, it has been registered years when the annual average precipitations, even though they had values around the multi-annual ones, their distribution caused agro-technical problems (retain of water in the soil), especially in the case of spring cultures. This fact represents a supplementary motivation to carry out this study, which can represent in the end a solution for these effects of global climatic changes.

MATERIAL AND METHOD

The study took place in vases with vegetation, and the work variants were: variant V_1 (control), to which it was not applied a treatment, V_2, treated with 100 kg ha^{-1}. Acuastoc, V_3 without treatment, but submitted to some periods of water stress, and V_4 treated with 100 kg ha^{-1} Acuastoc and submitted to some periods of water stress. The water stress was induced to plants after sunrise, starting with the phase of 4-6 leaves, by reducing the number of watering to half, comparing with the variants V_1 and V_2. The treatment with Acuastoc (100 kg ha^{-1}) took place with the sowing, and at the same time the fertilization also took place and, in a unique dose of Eurofertil Plus PHOS 38 (3.2 g per vase), administrated at the sowing depth.

In order to determine the *average height* of the plants, measurements took places 30 days after the sowing, during the period of vegetation and harvesting, for each variant in 6 repetitions.

The *chlorophyll content in leaves* was measured using the CCM 200 plus device from Opti-Science Company (*Figure 1*). It is a tool for measurements performed in the experimental field and makes precise, reliable and easy chlorophyll content determination of leaves. The device can store 4000 measurements performed with a detector with two photo-diodes with absorbance amplifier.

Figure1 **Device used for determining the chlorophyll content of leaves**
(http://www.envcoglobal.com)

Determinations were made in the upper third of the plants, in the middle thereof and in the lower third, in order to highlight more clearly the way in which the plant growth is influenced by the Acuastoc treatments. The device records the data in the internal memory, which are then downloaded to the PC, where they were processed using the ANOVA and the F test.

In order to determine the soil moisture *(U,%)* soil samples were collected from 0-5 cm, 5-10 cm and 10-15 cm depths, in aluminium vials, that were dried in the oven. The soil moisture at a given moment was calculated by dividing the evaporated water at the soil sample weight (1):

$$U\% = \frac{Ax100}{P} \qquad (1)$$

where, *U%* - soil moisture (%); *A* – water evaporated from the sample (g); *P* – dried soil weight (g).

RESULTS AND DISCUSSIONS

Influence of Acuastoc on the Chlorophyll content of the leaves

In order to better emphasize the benefits of Acuastoc for the growth and development of plants, the chlorophyll content of the leaves, which is closely interdependent with the other parameters analyzed in this paper, was determined. Water insufficiency in the rapid growth phase of the strain reduces the growth rate of the plant, the foliar surface and the chlorophyll content of the leaves.

In order to better capture the manner in which Acuastoc influences the chlorophyll content of the leaves we determined this parameter taking into account the corn plant morphology. It was determined at the level of the lower third of the plant, its median area and its upper third (*Figure 2*). The findings of our research showed that in relatively optimum moisture conditions, in the case of the control variant, the plants had a lower chlorophyll content in the median area compared to the upper and lower thirds, where the plants had approximately the same chlorophyll content. In the case of the variant treated with Acuastoc there was a higher content of chlorophyll in the median area of the plant, a lower chlorophyll content in the upper third area and a much lower chlorophyll content in the lower third area (*Figure 2*). Under water stress conditions (V_3 and V_4), approximately the same trend was noticed, with the difference that the discrepancies recorded between the three areas where this parameter was determined are much smaller (*Figure 2*).

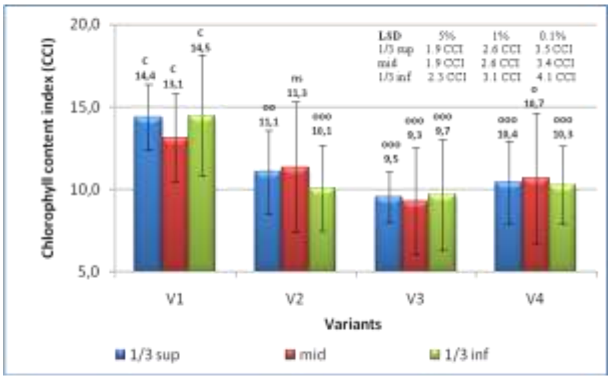

Figure 2 **The influence of Acuastoc on the chlorophyll content in maize**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

LSD – Least Sighificant Difference; C – control; ns – insignificant; o – negative significantly; oo – negative distinctly significant; ooo – negative very significant.

An analysis of the chlorophyll content of the leaves across the plant illustrates how this parameter is influenced by water stress. Thus, under relatively optimum moisture conditions, the plants had a lower chlorophyll content in the variant treated with Acuastoc (V_2) than in the control variant (V_1). This may be due to the competition for water and nutrients between Acuastoc and the plant roots. The situation was completely different in water stress conditions, and the plants had a higher chlorophyll content in their leaves in the treated variant V_4 than in the untreated variant V_3 (*Figure 3*). Our findings clearly suggest that the Acuastoc treatment is recommended especially in water stress conditions, since the differences detected, which were statistically significant, do not justify the treatment under optimum moisture conditions.

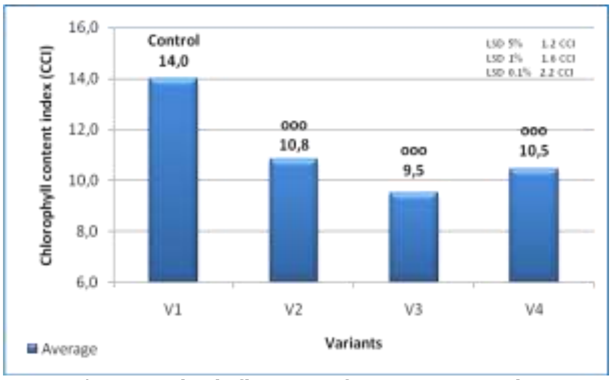

Figure 3 **The influence of Acuastoc on the chlorophyll content in maize (average on the plant)**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

LSD – Least Sighificant Difference; ooo – negative very significant.

Influence of Acuastoc on the Average plant height

The average plant height is a parameter that very accurately illustrates the plant’s supply in water and nutrients, as it was determined in dynamic conditions, because plants have different water requirements depending on their growth phenophase. Thus, Humlum J., quoted by Muntean L.S. *et al.*, 2003, claims that, considering the conditions in Romania, the production of grain per hectare may exceed the mean when precipitation is distributed as follows: over 40 mm in May, 60 mm in June, 60 mm in July and 80 mm in August.

According to our findings, in the variants treated with Acuastoc (V_2 and V_4), the plants were larger in comparison with the untreated variants (V_1 and V_3) in all the phenophases where this parameter was determined. Approximately 10 days after the controlled onset of water stress, the plants in the treated variants were about 3.3 cm larger than the variants not subjected to water stress and about 3.1 cm larger than those subjected to water stress (*Figure 4*). The same trend was noticed in the other phenophases in which this parameter was measured, with the difference that the discrepancies detected were smaller. It was also noticed that as the maize goes through its growing stages, it makes less use of the positive influence of Acuastoc in relatively optimum moisture conditions; in August, the plants on the treated variant (V_2) were 3.1 cm smaller than the control variant (V_1) (*Figure 4*).

In water stress conditions, the Acuastoc treatment has significantly contributed to the development of larger (V_3) plants, in comparison with the untreated variant (V_4). The statistically significant differences were 9.2 cm in July and 5.9 cm in August (*Figure 4*).

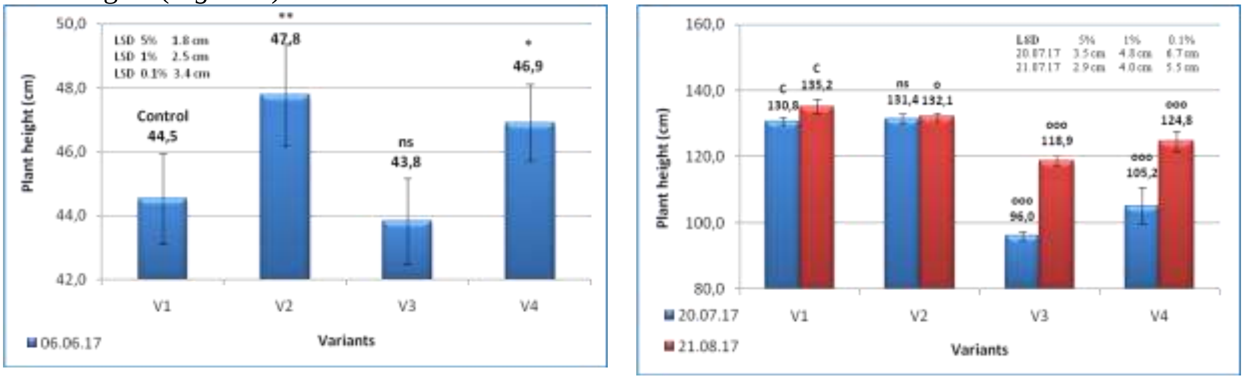

Figure 4 **The influence of Acuastoc on the average plant height in maize**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

*LSD – Least Sighificant Difference; C – control; ns – insignificant; * – significantly; ** – distinctly significant; o – negative significantly; ooo – negative very significant.*

An analysis of the average plant height over the entire growing period (*Figure 5*) clearly illustrates the need and usefulness of the Acuastoc treatment, especially under water stress conditions. 0.3 cm differences in relatively optimum humidity conditions and 6.1 cm differences in water stress conditions were detected between the treated (V_2 and V_4) and untreated (V_1 and V_3) variants (*Figure 5).*

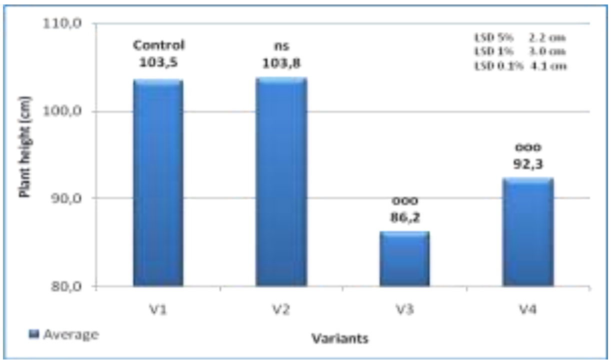

Figure 5 **The influence of Acuastoc on the average plant height in maize (mean values on growing stage)**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

LSD – Least Sighificant Difference; ns – insignificant; ooo – negative very significant.

Influence of Acuastoc on Soil moisture

Soil moisture, which is an important indicator for our research, was determined in dynamic conditions, at different depths: 0-5 cm, 5-10 cm and 10-15 cm. The findings revealed a positive influence of the Acuastoc treatment on soil moisture at all the depths at which it was determined, both in optimum water supply conditions (early August) and in water stress conditions (end of August). Thus, we noted that soil moisture varied at a depth of 0-15 cm depending on the water content of the soil. Thus, immediately after watering (beginning of August), in all variants studied, the highest soil moisture was in the 5-10 cm layer, followed by the 10-15 cm layer and 0-5 cm layer, respectively (*Figure 6*). When we determined soil moisture before watering (end of August), a different distribution of humidity was detected in the 0-15 cm range, with fluctuations varying with the Acuastoc treatment and general growing conditions (induced water stress and temporary water stress), as illustrated in *Figure 6*.

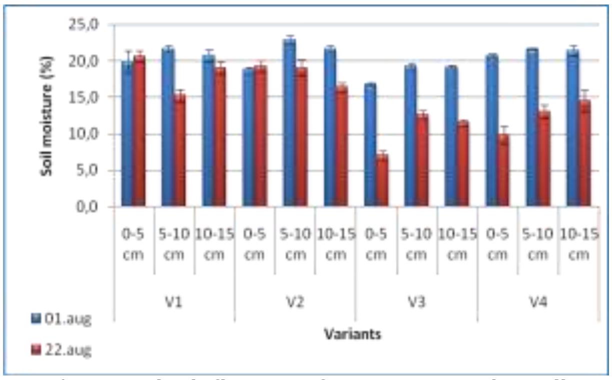

Figure 6 **The influence of Acuastoc on the soil moisture in maize crop**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

Observations made on the 0-15 cm range have more clearly revealed the trend noted in figure 6. When the active humidity range was optimally ensured (right after watering), the highest humidity was recorded in the Acuastoc-treated variants (V_2 and V_4), with very small differences between them, of only 0.1%, and compared to the control variant V_1 of approximately 0.4% (*Figure 7*). In the context in which the active humidity range was not optimally ensured (prior to watering), a significant decrease in soil moisture was detected, especially in variants subjected to artificially induced water stress, in variant V_3 from 18.3% to 10.4% and in variant V_4 from 21.2% to 12.4%. In the same context, i.e. when the optimum active humidity level is not reached, in case of variants temporarily subjected to water stress (before watering), the differences are 2.5% for the control variant V_1 and 2.9% for the variant V_2 (*Figure 7*).

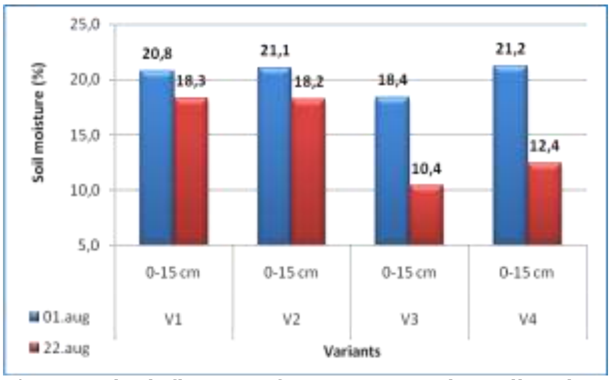

Figure 7 **The influence of Acuastoc on the soil moisture in maize crop (mean values 0-15 cm)**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

An analysis of soil moisture over the entire growing stage, at different depths, shows that in relatively optimum humidity conditions, in the untreated variant V_1 (considered as control variant), the highest humidity level is achieved in the 0-5 cm and 10-15 cm layers. In the variants treated with Acuastoc we noticed the exact opposite, namely the highest humidity was detected in the 5-10 cm layer (21.0%), as compared to 19% in the 0-5 cm and 10-15 cm layers (*Figure 8*). In the variants subjected to water stress, soil moisture had higher values in the 5-10 cm layer in variant V_3 (15.9%) and 10-15 cm in variant V_4 (18.0%). These aspects may be accounted for by the fact that something happens in the variants subjected to relatively optimum humidity conditions (V_1 and V_2) at sowing depth and at Acuastoc incorporation depth, respectively. Thus, the untreated variant had higher water consumption in certain plant growth and development phenophases, whereas when Acuastoc was incorporated (5-10 cm), it created an additional water reserve (*Figure 8*).

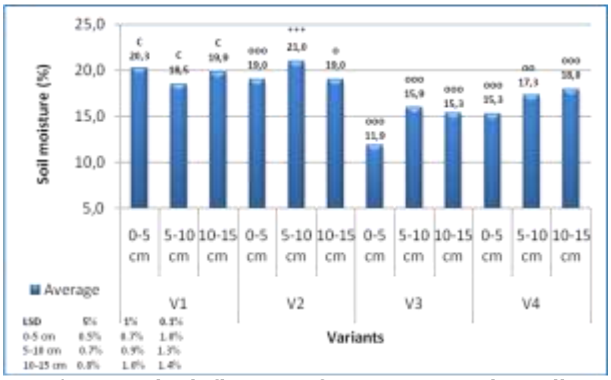

Figure 8 **The influence of Acuastoc on the soil moisture in maize crop (mean value on growing stage)**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

*LSD – Least Significant Difference; C – control; o – negative significantly; oo – negative distinctly significant; ooo – negative very significant; *** - very significant.*

As concerns the water needs of maize, authors like Oancea I., 2003 or Lăzăroiu A. *et al.*, 2008 argued that prior to the appearance of the panicle, maize grows best when the moisture reserve is above the minimum 70% threshold of the active humidity index. During this period, the presence of precipitation or irrigations of crops are welcome, as during this period the daily average water consumption is 5.5-5.6 mm/day. Thus, by introducing in the crop technology some actions that either determine the water content of the soil or maintain soil moisture at about 70% of the active humidity index, one may achieve a significant increase in production. During grain formation, water consumption is high, being about 35-45 m^3/ha/day (Oancea I., 2003). If it is provided with sufficient water during this period, the plant achieves a good yield in terms of substances photosynthesized in the grain. In this period, excessive heat associated with insufficient soil moisture causes the average weight of the grain to decrease and the occurrence of the grain shredding phenomenon. Maintaining soil moisture below 50% of the active humidity index resulted in a 49% reduction in the plant production level, although the plants received enough water during the previous stages (Lăzăroiu A. *et al.*, 2008).

In the case of variants subjected to artificially induced water stress starting with the 3-4 leaf stage in maize, a relatively uniform distribution of soil moisture was noted on a 5-15 cm depth, with differences between the 5-10 cm and 10-15 cm layers of 0.6% for variant V_3 and of 0.7% for variant V_4 (*Figure 8*). In the top 0-5 cm layer, the statistically significant differences were bigger, namely 4% for the untreated variant (V_3) and 2% for the Acuastoc treated variant (V_4), which also shows the positive influence of treatment especially under water stress conditions.

An overall analysis of soil moisture values as a mean on depth and growth stages illustrates more clearly the positive influence of Acuastoc on this parameter, especially under water stress conditions. Thus, the differences recorded between the treated and untreated variants are 0.2% in relatively optimal humidity conditions and 2.4% under water stress conditions (*Figure 9*).

These findings encourage us to claim that the Acuastoc treatment may be effectively used in maize crop technology, especially in a fluctuating climate with a relatively uneven distribution of precipitation.

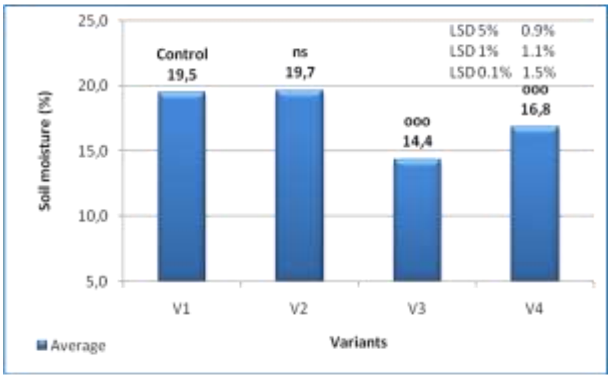

Figure 9 **The influence of Acuastoc on the soil moisture in maize crop (mean value on depth and growing stage)**

(V_1 - untreated (control); V_2 – 100 kg ha^{-1} Acuastoc; V_3 - untreated, hidric stress; V_4 - 100 kg ha^{-1} Acuastoc, hidric stress)

LSD – Least Sighificant Difference; ns – insignificant; ooo – negative very significant.

CONCLUSIONS

In conclusion, we can appreciate that Acuastoc has perspectives of being used with success in the durable technologies of sowing plants, it has the capacity to belate the appearance of the critical threshold for draught and it becomes efficient especially in case of moderate draught conditions. Also, we consider that it becomes efficient and it is justified to apply it when the non-uniform distribution of precipitations manifests, because in normal conditions of humidity, the increase registered does not justify economically its administration. On the other hand, the administration of Acuastoc can be seen as an insurance policy against unwanted events (moderate draught or non-uniform distribution of the precipitations), because its remanence and efficiency in soil is of over three years.

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